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Evaluation of Lightness in Linen and Semi-linen Fabrics

Liucina KOT *, **Eglė KUMPIKAITĖ, Audronė RAGAIŠIENĖ, Žaneta RUKUIŽIENĖ**

Faculty of Design and Technology, Kaunas University of Technology, Studentų str. 56, LT-51424 Kaunas, Lithuania

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Lightness of textiles is one of the main "white" product quality indicators described by the following parameters: lightness of a colour, colour tone, colour uniformity and stability under the influence of physical factors. "White" textile products can be perceived by comparing them with a standard (Pantone colour palette). On the other hand, the lightness of the fabric can be estimated using the colorimeter and determining lightness of a fabric *L*. The purpose of a research is to assess the lightness of a linen and semi-linen fabric using two different methods, to carry out a comparative analysis of the results and to associate fabric lightness with the fabric structure parameters. Two methods were used for experiment (colorimeter Spectraflash CF 450X and judges' assessment of lightness). The analysed colours of a fabric were divided into five colours of grey scale: white, whitish, light grey, grey and dark grey. During examination of two methods different results were obtained: testing with colorimeter, white colour was found in only one fabric, while the judges found the fabrics of white colour much more. Establishing of white and dark grey colours was the most difficult for judges. Fabric lightness *L* was associated with fabric structure parameters – the warp and weft settings and fabric weave. It was found that these fabric structure parameters affect the lightness of a colour of a fabric *L* very little or do not affect.

Keywords: linen fabric, lightness, colour, warp and weft settings.

INTRODUCTION

Colour is property of things creating the sense of sight, corresponding to the objects emitted, reflected, omitting light spectral composition and intensity. According to beam-wave absorption, reflection, or omission colours are grouped into achromatic and chromatic. Neutral colours (black, white, grey, and all of their tones) are achromatic [1].

C. Agudelo, M. Lis and J. Valldeperas analysed the change of a fabric discoloration using different concentration of two- and three-component mixtures of colours, while maintaining the same shade. Dependency of a 100 % PES fabric discoloration was tested. Fibres of a greater diameter are more exposed to the kinetic energy in dying process, which can improve the reproducibility of fabric dying [2].

V. Rubežienė et al investigated the samples of woodland camouflage materials seeking to evaluate their camouflage effectiveness in visual and near IR radiation spectral ranges. The colour changes were established with spectrometer and using photo simulation and spectral analysis. The last method was applied for determination of the efficiency level of various woodland camouflage materials dyed and printed using different technologies. Using three different printing technologies the results showed that even noticeable changes of colour intensity after some pretreatments in the visual spectral range, in many cases does not have signifficant influence on the spectral reflectance in the near infrared range and it remains in the required level [3].

S. Samorokova and V. Dobilaitė investigated the influence of different fade regimes on linen fabrics of different structures by determining the influence of wet bleaching regimes on linen fabrics fade finishing efficiency, colour change, whiteness index values. The significant colour changes were recorded when the temperature rises from 67.5 °C to 95 °C [4].

H. Gabrijelčič and K. Dimitrovski performed the measurements of colour parameters of fabrics of various weaves and setting, analyzing the changes of colour. Spectrophotometric method objectively determines surface colour values of fabrics woven from different colours warp and weft yarns. When the fabric structure parameters are known, the colour values can be predicted due to the colour change has the linear dependence on the warp and weft settings, and the linear density [5, 6].

J. Musnickas et al studied an influence of non-ionic auxiliary agents on absorption, dyeing wool fabric in different dyes (fabrics were dyed by method of colorant absorption), as well as colour washing resistance. Speed of dyeing and colour soaking to the fabric improves at 60 °C temperature. Increasing the dying temperature from 60 °C to 85 °C the colour of wool fibre changes. The test results showed the diffusion of woollen fabric dye into the whole fibre volume. Assessing general change of a colour it was found that the most significant effect on the staining inequality has the influence of a temperature variation [7].

A. Cay, R. Atav and K. Duran carried out colour measurements using spectral photometer by analyzing cotton fabrics with different warp and weft settings and dyed with chemically reactive dyes. By increasing of the setting of fabric dye penetration into the fabric becomes more difficult. When setting of the warp and weft increased, the colours of a dyed fabric become lighter [8].

According to N. P. Sonaje and M. B. Chougule, evaluation of the product whiteness depends on the whitening technology. In the process of bleaching the colours are chemically removed from the other fabrics by obtaining a more even result of a spectral reflection. In the process of study an index of a whiteness of cotton fabrics

* Corresponding author. Tel.: +370-37-353862; fax.: +370-37-353989.
E-mail address: *liucina.kot@gmail.com* (L. Kot)

was determined. Pilot treatment plant water, Municipal Tap water and Ground water were used for bleaching. It was established that the waste water bleaches the cotton fabrics best of all. The whiteness index was calculated by Computer Color Matching (CCM) technique [9].

Fabric properties as well as colour properties can be influenced by weaving technique and conditions as well as by warp initial tension [10, 11].

Therefore, the research of fabrics of various raw material and the colour parameters of knits were made. They were mostly involved in various technological parameters on the changes of the colour of a fabric and whiteness index. However, studying the colour of linen and semi-linen fabrics, a problem of evaluating of bleached in various degrees fabric colour occurred. While linen and semi-linen fabrics of all shades are often referred collectively as “white”, but not all of the fabrics are of pure white colour. This is the reason why it is important to choose the method of assessment of the lightness of a fabric and to relate the parameters of a fabric colour with its structural parameters.

METHODS

The object of investigation are 50 linen and semi-linen fabrics from founds of Lithuanian Open Air Museum. There were 39 towels and 11 fabric pieces investigated because of large dimensions of other fabrics. The fabrics were weaved in 5 different weaves – plain, overshot, diamond twill, checked twill and checked satin. Their warp setting differs from 11 dm^{-1} to 22 dm^{-1} and weft setting differs from 12 dm^{-1} to 22 dm^{-1}. The fabrics were bleached in different degrees or not bleached, i. e. of natural flax colour.

Weaves and settings of fabrics were established using needle and counting glass.

Evaluation of fabrics lightness was made by two different methods. The first method was carried out by evaluating of judges. This method was chosen because lightness of fabrics is evaluated the most often by specialists comparing the fabric with the colour palette Pantone. The judge panel was formed of 10 persons. All of them were textile specialists (lecturers and students). 5 of them were 20 – 30 years old; 3 the judges were of 30 – 40 age group and 2 the judges were from 40 – 50 age group. At first the judges were get acquainted with the assessment condition and technique. It was made the colour palette of 5 different colours of grey scale: white, whitish, light grey, grey and dark grey colours. This palette was always against the judges during evaluation of colour of the fabrics. Thus, the judges could compare the colour of single sample with the colour from established palette of grey scale, if it was necessary. The samples of fabrics of each colour are shown in Fig. 1. The judge panel estimated colour of fabrics at the same day, time and light. Enlightenment was of day light.

Summarising the results of experiment the average values, deviations and variation coefficients of each colour were calculated. Compatibility of judges’ opinion was established according to variation coefficient, which evaluates the differences of assessment of each colour. When $v \leq 0.10$, the accordance of judges is high. When $v = 0.11 \div 0.15$, the accordance is higher than medium. When $v = 0.16 \div 0.25$, the accordance is medium. When $v = 0.26 \div 0.35$, the accordance is lower than medium. When $v \geq 0.35$, the accordance is low. This method is described more precisely in references [12 – 14].

Also fabric lightness was established by another method, i. e. using colorimeter “Datacolor Spectraflash SF450X” according to the standard EN ISO 105-J01. This colorimeter is a dual-channel spectrophotometer designed to measure colour in both reflectance and transmittance mode at 10 nm intervals within the visible spectrum (360 nm – 700 nm). The experiment was carried out by enlightenment of day light D65 10°, measurement area was 9 mm. Three different places of fabric were measured. CIELAB colour coordinates were established during measurement. However just parameter *L*, which shows fabric lightness, was used in investigation for evaluating of fabric lightness. According to the measured by device fabric lightness was distributed into 5 groups: white colour – lightness changes from 100 to 90, whitish colour – from 90 to 80, light grey – from 80 to 70, grey colour – from 70 to 60, dark grey colour – from 60 to 50.

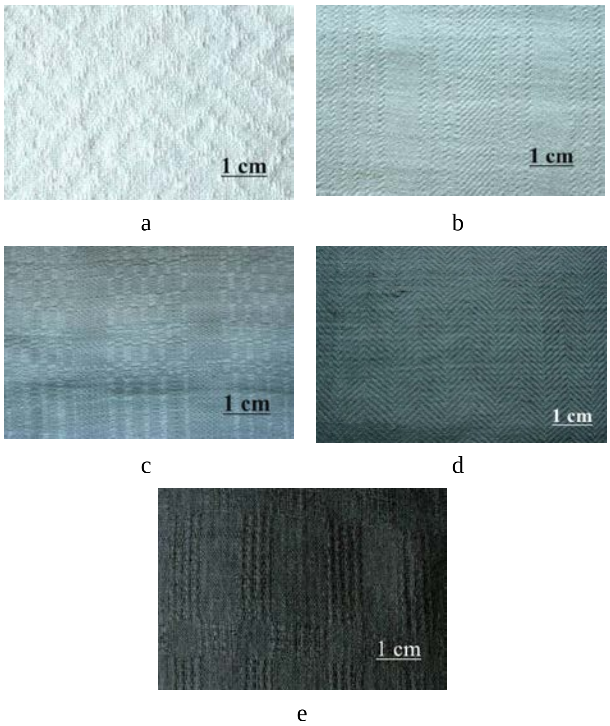

Fig. 1. Colours evaluated by judges: a – white colour (piece of fabric LBM 45267); b – whitish colour (towel LBM 48187); c – light grey colour (towel LBM 7981); d – grey colour (towel LBM 2831); e – dark grey colour (piece of fabric LBM 31331)

Graphical analysis of data was made using software packet Microsoft Excel.

RESULTS

There are a number of variables that influence the apparent color of the final textile product. These include fiber variability, yarn and fabric constructions, or fabric wet processing techniques [15].

It was noticed that it is difficult to evaluate real colour of fabrics, especially if they are of grey scale colour. The main problem of evaluation of lightness is in assortment of a linen and semi-linen fabric. A fibre flax and textile garments of them often are called as “white”. But it is known, that these fibres are not of real white colour. Naturally they are grey with different shades of this colour. Colour of linen fabrics depends on flax preparation, temperature and humidity, air conditions, sun shine, microbial retting time etc. So, colour of flax fibre consists from many shades of grey colour. The variety of flax colours is transmitted in this article.

Besides, colour of linen fabrics is influenced by different fade regimes [5].

In this research the colour evaluation of linen and semi-linen fabrics were obtained by 10 judges at first. The results of investigation are shown in Table 1, where evaluation of each judge, average value, deviation and variation coefficients of each colour are presented. It can be seen that the variation coefficients of each colour are very different. The least variation coefficient is in the case of light grey colour (just 0.03), so the accordance of judges is high. In the cases of grey (variation coefficient is 0.11) and whitish (variation coefficient is 0.13) colours the higher than medium accordance of judges was established. The medium accordance (variation coefficient is 0.22) was estimated for white colour. And the low accordance (variation coefficient 0.80) was for dark grey colour of investigated fabrics. It can be stated that the most difficult for judges it was to establish dark grey and white colours, because variation coefficients of these colours are the highest.

Table 1. Results of colour evaluation by judges

Judges	White	Whitish	Light grey	Grey	Dark grey
1	5	13	19	11	2
2	6	14	18	11	1
3	4	15	17	11	3
4	6	12	18	10	4
5	6	16	18	9	1
6	5	15	18	8	4
7	3	12	19	10	5
8	5	14	17	10	4
9	4	13	19	9	5
10	4	13	18	11	4
Sum of scores	48	137	181	100	34
Average sum of scores	30				
Average score	4.8	13.7	18.1	10	3.4
Deviation	1.03	1.34	0.74	1.05	1.65
Square deviation	1.07	1.79	0.54	1.11	2.71
Coefficient of variation	0.22	0.13	0.03	0.11	0.8

The cases of dark grey and white colours are analysed separately and more precise. The judges results of dark grey colour are shown in Fig. 2. It can be seen that the results vary from 1 (for second and fifth judges) to 5 (for seventh and ninth judges). Such results show, that the variation of dark grey colour is high as well as show the variation coefficients. The reason of such results is that amount of dark grey fabrics is small and the variation of results is more visible.

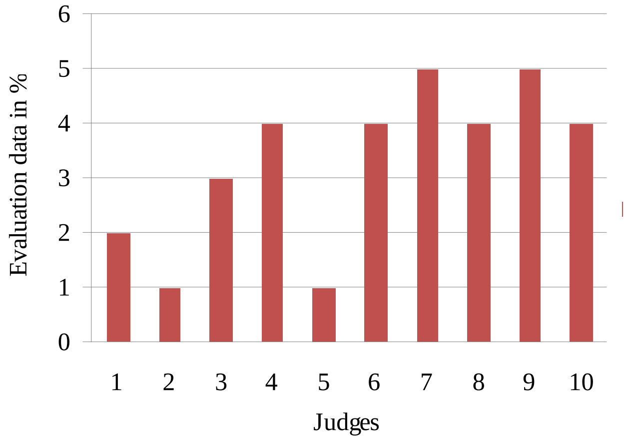

Fig. 2. Evaluation of dark grey colour of judges

The results of judges evaluation of white colour are shown in Fig. 3. It can be seen that different judges evaluate white colour in different way as well as in the case of dark grey colour. The amount of light fabrics was larger and the variation of white colour is lower than in the case of dark grey colour. Also the value of variation coefficient confirms these results – the variation is medium. Individual human observer can recognize differences between colours in different way [15], especially when we have the colour palette of grey scale. This is because of very similar shadows of neighbouring colours.

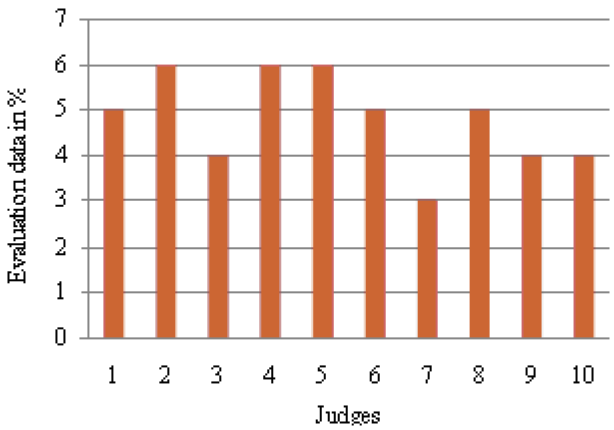

Fig. 3. Evaluation of white colour of judges

In the next stage of investigation lightness parameter *L* of linen and semi-linen fabrics was obtained by colorimeter. The lightness parameter deviations values varied from 0.119 to 3.569. The colour evaluation of judges and DataColor device is seen in Fig. 4. In blue columns average of the judges’ opinion is shown. It can be seen that results of DataColor device and judges are different. Device found the largest amount of whitish colour and judges the most amount of fabrics attributed to light grey colour. Evaluation of every colour differs for a few times – 4.9 times for white colour, 2.5 times for whitish colour, 3 times for light grey colour, 3.3 times for grey colour and 1.5 times for dark grey colour. Thus, the differences of each colour are also very large and distributed accidentally in the cases of two analysed methods. It can be stated that from the comparison of two methods of fabrics colour evaluation that results of different methods (the most usual in practice by judges and by the colorimeter results) give quite different results and it is difficult to choose the one of these methods for precise evaluation of fabrics colour.

These results do not coincide with the results of [13] because in this reference results of judges' evaluation and textile hand experimental evaluation are much closer than in this research. The reason of such results can be that differences of hand property of chosen fabrics are more visible than the changes between colours of grey scale, especially when light colours (white and whitish) are evaluate.

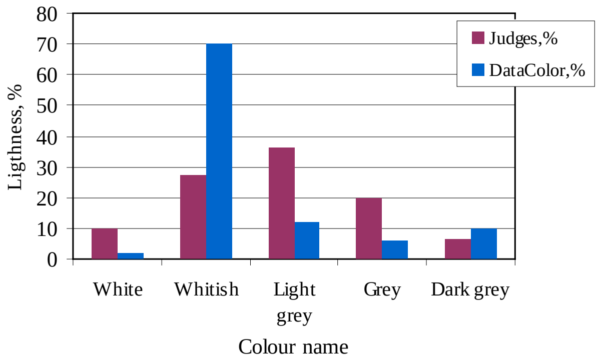

Fig. 4. Colour evaluation of DataColor device and judges

Because of such results, it was decided to investigate how parameters of fabric structure influence on parameter of lightness. The determination coefficients of influences of warp and weft settings on investigated fabrics lightness for different weaves are presented in Table 2.

Table 2. Determination coefficients of influences of warp and weft settings on lightness of all weaves evaluated by DataColor device and judges

Weaves	R^2			
	DataColor		Judges	
	S_m	S_a	S_m	S_a
Plain	0.004	0.561	0.642	0.042
Overshot	0.061	0.271	0.096	0.005
Diamond twill	0.342	0.779	0.004	0.315
Checked twill	0.032	0.026	0	0.041
Checked satin	0.769	0.549	0.753	0.531

It can be seen from the Table 2 that determination coefficients of checked satin warp and weft settings are medium, but the most of determination coefficients are lower than 0.5. Warp and weft settings of overshot and checked twill weaves do not influence on fabric lightness for both, DataColor device and judges evaluation methods. The best relationships are shown and discussed bellow.

Influence of warp and weft settings on fabric lightness of checked satin weave evaluated by DataColor device and judges are presented in Fig. 5 and Fig. 6. Influence of warp setting is described by linear equations with determination coefficients 0.7685 for DataColor device and 0.7531 for judges evaluation, i. e. the influence is medium. Thus, it can be stated that in this case the evaluation of DataColor device and judges is of similar accuracy.

It can be seen from Fig. 6 that the influence of weft setting on fabric lightness of checked satin weave are low, but they are of similar accuracy for both, DataColor device and judges evaluation.

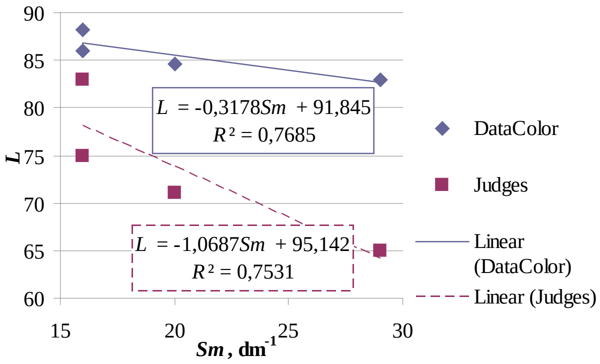

Fig. 5. Influence of warp setting on fabric lightness of checked satin weave evaluated by DataColor device and judges

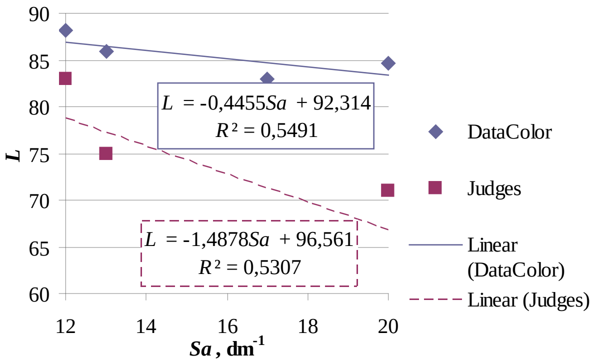

Fig. 6. Influence of weft setting on fabric lightness of checked satin weave evaluated by DataColor device and judges

It is estimated that these results are influenced by the fact that floats of satin weave are sufficiently long; the warp and weft yarns are less linked to each other. Because of this reason floats make more shadow on the surface of the fabric with the increasing of thread settings and lightness L decreases.

Influence of weft setting on fabric lightness of diamond twill weave is shown in Fig. 7.

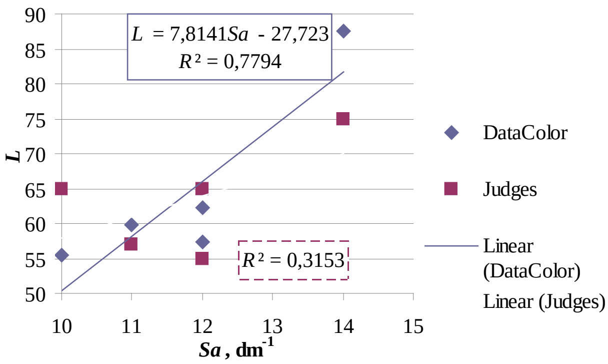

Fig. 7. Influence of weft setting on fabric lightness of diamond twill weave evaluated by DataColor device and judges

DataColor device shows better results than judges' evaluation because determination coefficient of DataColor device is higher.

The intensity of wool fabrics colours and lightness parameter were investigated in [7]. The character of results variation of different structure fabrics is similar to the results in this article. The increase of weft and warp settings on the lightness *L* was investigated by researchers in [6]. It was found that weft setting has the main effect on the *L* values of the samples. Due to the increase of weft setting, the fabrics become denser, and this makes the penetration of the dyestuffs into the fabric more difficult. On this account, fabrics with higher weft setting show higher *L* values. Maybe, such strong dependencies of these parameters are of settings chosen purposive.

CONCLUSIONS

1. Usually colour shade of fabrics is evaluated by using colorimeter or by the panel judge. The results of these two methods can be compared. It was estimated that results of DataColor device and judges are different.
2. It was established five colours of grey scale: white, whitish, light grey, grey and dark grey. The most difficult for judges it was to establish dark grey and white colours, because variation coefficients of these colours are the highest.
3. After investigating of influence of fabric warp and weft settings on lightness, it was estimated that medium influences were for diamond twill fabrics weft setting of DataColor device (R^2 = 0.779), checked satin fabrics warp setting of DataColor device (R^2 = 0.769) and checked satin fabrics warp setting of judges evaluation (R^2 =0.753).
4. Warp and weft settings of overshot and checked twill weaves do not influence on fabric lightness for both, DataColor device and judges evaluation methods.

Acknowledgments

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